6. EDUCATION AND PUBLIC OUTREACH

The Laboratory for Atmospheres actively participates in NASA's efforts to serve the education community at all levels and to provide information to the general public. The Laboratory's educational outreach component is consistent with the Agency's objectives to enhance educator knowledge and preparation, supplement curricula, forge new education partnerships, and support all levels of students. Laboratory activities include addressing public policy, establishing and continuing collaborative ventures and cooperative agreements; providing resources for lectures, classes, and seminars at educational institutions; and mentoring or academically advising all levels of students. Through our public outreach component, we seek to make our scientific and technological advances broadly accessible to all members of the public and to increase their understanding of why and how such advances affect their lives. Education and public outreach are an important part of our basic science activities and go hand in hand with our work on projects, field campaigns, instrument development, modeling, data analysis and data set development. This section highlights some of the education and public outreach activities of our Laboratory.

Interaction with Howard University and Other Historically Black Colleges and Universities

A part of NASA's mission has been to initiate broad-based aerospace research capability by establishing research centers at the nation's Historically Black Colleges and Universities (HBCUs). The Center for the Study of Terrestrial and Extraterrestrial Atmospheres (CSTEA) was established in 1992 at Howard University (HU) in Washington, D.C., as a part of this initiative. The Laboratory for Atmospheres started a close collaboration with CSTEA in their second 5-year period of NASA funding under a cooperative agreement grant. It has been a goal of the Laboratory and the Earth Sciences Directorate to partner with CSTEA to establish at Howard University a self-supporting facility for the study of terrestrial and extraterrestrial atmospheres, with special emphasis on recruiting and training underrepresented minorities for careers in Earth and space science. Some of the Laboratory's continued research and educational activities with Howard University's CSTEA program during 2002 are highlighted below.

Howard University students in the CSTEA program were invited to give poster presentations on April 22 in the building 28 atrium at Goddard. The visit was sponsored by Magui Cardona, Stokes Fellow in the Minority University Programs office at Goddard. Scientists from codes 900, 600, and 500 were invited to the poster session. The students and Prof. Venable, CSTEA's head, were treated to an E-theater presentation by the Laboratory's Fritz Hasler.

Marshall Shepherd and members of the Howard University Physics Department (Prof. Joseph and Prof. Venable) installed 3 tipping-bucket rain gauges. Two rain gauges were installed at the Howard University Beltsville facility and one gauge on Howard's downtown campus. Marshall Shepherd contributed the gauges (1) to foster his ongoing investigations of urban/rural rainfall anomalies and rainfall variability and (2) to foster continued partnerships with Howard University and the Laboratory for Atmospheres.

The Laboratory works closely with CSTEA faculty to promote the Howard University Program in Atmospheric Sciences (HUPAS). HUPAS is the first M.S.- and Ph.D.-granting program in atmospheric sciences at an HBCU and the first interdisciplinary academic program at Howard University. Scientists from our Laboratory contribute to the HUPAS program as lecturers, advisors to students, and adjunct professors teaching courses. Laboratory for Atmospheres Adjunct Professors Dean Duffy and Richard Stewart wrote parts of the first Ph.D. candidacy exams for HUPAS. The Laboratory's adjunct professors Dean Duffy, Richard Stewart, and Walter Hoegy have attended HUPAS committee meetings to discuss future plans, course offerings, and qualifying exam sched-

ules for the Howard graduate degree program in atmospheric science. After a second round of qualifying exams, 6 Howard students are now on track for earning the Ph.D. in the atmospheric sciences.

The Laboratory continues its enthusiastic support for the Goddard Howard University Fellowship in Atmospheric Sciences (GoHFAS) program. GoHFAS was established in 1999 to broaden and strengthen the research and educational opportunities of underrepresented minorities. The students attend a summer program at Howard University where they engage in research with mentors at HU, GSFC, or NOAA. They receive fellowships at their home institutions during their senior year and are given an opportunity to come to HU during the winter break to continue their research.

Summer Programs

Our Laboratory participates in a number of programs that bring graduate, undergraduate, and high school students to work one-on-one with scientists and engineers in the Laboratory for Atmospheres as well as in other Laboratories and Directorates at Goddard. Our Laboratory also hosts groups for tours of our facilities and lectures to inspire interest in Earth sciences. GoHFAS collaboration with Howard University was mentioned in the previous section. The Summer Institute on Atmospheric and Hydrologic Sciences is the longest running program sponsored by the Earth Sciences Directorate. The Graduate Student Research Program in Earth Sciences, run by GEST, is a successful program that exposes students to the most current research topics in Earth science. Information on this program can be accessed at the Web site (http://www.umbc.edu/gest/) under Student Opportunities. Information on programs sponsored by the Goddard Office of University Programs can be accessed at http://education.gsfc.nasa.gov/. Information on Earth science-related programs may be obtained from http://earthsciences.gsfc.nasa.gov/edu/. These programs are designed to stimulate interest in interdisciplinary Earth science studies by enabling selected students to pursue specially tailored research projects with Goddard scientific mentors. Some examples of student mentoring are given below, followed by examples of summer visiting activities.

Summer Student Mentoring

Judd Welton mentored Torreon Creekmore, a senior from Elizabeth City State University in North Carolina. The student participated in the Goddard Space Flight Center Howard University Fellowship in Atmospheric Science (GoHFAS) program during summer 2002 and winter of 2003. He worked on the construction of the next generation micro-pulse lidar prototype. Mr. Creekmore is expected to return in summer 2003 to continue work on the next phase of the prototype, including data processing.

Kent McCullough mentored a rising junior from the University of Maryland in the area of instrument fabrication.

Richard Lawrence mentored a junior from UMBC in the Summer Institute program on the subject of temporal sampling error analysis of monthly radar rain rate maps.

Tom Bell mentored a UMBC senior on TRMM sampling error estimates.

William Lau mentored a beginning graduate student from SUNY Stony Brook on climate analysis. The student worked on identifying regional rainfall variability for model validation and carried out climate data analysis using Empirical Mode Decomposition. This modeling was applied to rainfall trends in northern and central China.

Kazem Omidvar mentored a junior from Skidmore College, Saratoga, on the subject of Symmetric Charge Transfer Cross Section Calculation for O+-O collisions, and Dr. Omidvar and the student submitted the research results to the Journal of Chemical Physics.

Lorraine Remer mentored a graduate student from CSU on atmospheric science.

Summer Visits

High School—SHARP: On April 16, Andrew Negri took part in a review of over 150 applications for the 2002 summer high school program known as SHARP, and 20 finalists and 15 alternates were selected. The request came from Dillard Menchan, Chief, Equal Opportunity Program Office.

GoHFAS summer students: Six students in the Howard University GoHFAS program visited our Laboratory for a tour of our experiment labs and the visualization lab. Dan Harpold gave a presentation on the activities of the Atmosphere Experiment Branch discussing the wide use of mass spectrometers in planetary exploration and everyday science. Matt McGill, Judd Welton, Tim Berkoff, and Stan Scott guided a tour through the Mesoscale Atmospheric Processes Branch lidar lab. Tom McGee discussed the AROTAL instrument that flew on the DC-8 during SOLVE. Marshall Shepherd gave a visual presentation in the Code 912 Visualization Lab, assisted by Mike Manyin. Finally, Si-Chee Tsay gave an inspiring talk on his SMART instrument in his new traveling lab (trailer). After the visit, two GoHFAS students held discussions with their new mentors. Annette Marerro from Universidad Metropolitana worked with Amita Mehta in Bldg 22, and Torreon Creekmore from ECSU worked with Judd Welton, Tim Berkoff, and Stan Scott in the Code 912 lidar lab.

AMS Student Fellowship Winners visit: On July 18, 10 AMS fellowship winners visited our Laboratory. The students were given a number of science presentations on long-term drought by S. Schubert, Amazonian deforestation by A. Negri, urban weather systems by M. Shepherd, the perfect dust storm by Si-Chee Tsay, all about Aura by A. Douglass, and carbon dioxide by A. Andrews. M. Shepherd and M. Manyin gave a GIS visual presentation. After lunch, the students toured Tom McGee's AROTAL Lidar lab.

Morgan State U., Polytechnic U. of Puerto Rico, and Howard U. student visit: On July 12, about 30 students visited Code 900. The visit was organized by Magui Cardona of the Goddard education office. Walter Hoegy welcomed the students and gave a brief outline of the activities of Code 900. Nancy Maynard gave a "Healthy Planet" presentation, followed by a GIS demo by Fritz Hasler. In the afternoon, Pat Coronado gave a presentation on "Unmanned Vehicles" and finally the students were given a lab tour by Dan Harpold and Tom McGee.

University Education

At the university level, Laboratory scientists have taught undergraduate and graduate courses, given seminars and lectures, and advised degree-seeking students.

Seminars/talks given at educational institutions:

Institution	Subject	Speaker
U. of Alabama, Huntsville	Use of Raman lidar in atmospheric studies	Dave Whiteman
George Mason University	Introduction to AIRS and Cr	Joel Susskind
U.S. Naval Academy	Remote Sensing Research at GSFC	Geary Schwemmer
U. of Nairobi, Kenya; Kenya Meteorological Dept.	Satellite observations for environmental assessment, disaster mitigation, resource surveys	Charles K. Gatebe
Howard University	GPS and Atmospheric Applications	Dev Roy
U. of Illinois, Urbana Champaign	Satellite remote sensing of clouds	Tamas Varnai
Penn State University	Ozone Observations from Space	Richard McPeters
National Central University, Taiwan	Earth Science Enterprise at NASA	William K.-M. Lau
Howard University	Aerosol Absorption measurements from TOMS	Omar Torres
UMCP, Meteorology Dept.	Use of ultraviolet observation to measure aerosol absorption from space	Omar Torres
UMCP, Meteorology Dept.	Progress in Global Rainfall Estimates	George Huffman
Texas A&M; UC-Irvine	Ozone	Anne Thompson
Maryland Space Grant Consortium, Johns Hopkins University	Remote Sensing Observations of the Atmosphere	Marshall Shepherd
University of Virginia	Overview of GPM mission	Marshall Shepherd
University of Virginia	Urban-induced Rainfall Anomalies in Houston	Marshall Shepherd

Other Education/Outreach Seminars:

Educational Group	Location	Subject	Speaker
Professors at small Colleges and Universities	GSFC	Stratospheric Ozone Change	Charles Jackman
Middle School & High School Teachers	GSFC	Stratospheric Ozone Change	Charles Jackman
Graduate Student Summer Program Seminar Series	GSFC	Ocean Surface Fluxes	Mark Helfand
Teachers in the Web Watchers Earth and Space Science program	Goddard Visitors Center	Aerosols and Global Cooling	Yoram Kaufman

Examples of Courses Taught

Chris Barnet taught a class of 5 students in computational physics (PHYS 640), spring 2002, at the University of Maryland Baltimore County (UMBC), where he is an Associate Research Professor. He also gave 3 guest lectures for PHYS 722 and PHYS 622 in spring of 2002.

Thomas Rickenbach taught Geography 311 on weather and climate to a class of 40 students at UMBC/JCET. He is a Research Assistant Professor in the Department of Geography and Environmental Systems.

William Lau taught a class of 10 students in climate modeling at the Hong Kong University of Science and Technology, where he is an Adjunct Professor of Mathematics.

Omar Torres taught a class of 4 students in atmospheric remote sensing in the Physics Department at UMBC where he is a Research Associate Professor.

Alexander Marshak taught a class of 4 students at UMBC in atmospheric radiation.

Dean Duffy taught physical meteorology to 2 students at Howard University. Dr. Duffy is an Adjunct Professor in the Physics Department at Howard.

Yoram Kaufman was a member of the organizing committee and a lecturer of a summer course on aerosols at NCAR, led by Bill Collins. About 30 graduate students (2 from GSFC) participated in the course.

Arthur Hou visited the Atmospheric Science Department of Colorado State University (CSU) where he gave four class lectures on data assimilation and use of satellite rainfall observations to improve climate modeling and analysis. The CSU invitation was accepted in the interest of Goddard outreach to attract able students from a leading atmospheric science department and to form research collaborations under an existing co-op agreement between the two institutions. CSU provided the DAO with the code for CSU's Cloud, Convection, & Radiation Physics model for implementation in the fvDAS, and is working on the adjoint model of the CSU cloud scheme for the DAO and ECMWF.

K-12 Education

Laboratory staff participated in K-12 education in a variety of ways. Laboratory scientists routinely present lectures and demonstrations to K-12 schools and youth groups to help develop an early interest in science. Many Laboratory scientists have also mentored students in grades K-12. Examples of these educational activities are given below.

Chris Barnet participated in the Career Day at Eleanor Roosevelt High School. George Huffman reviewed grade 5–6 Earth science curriculum modules for the Challenger Center for Space Science Education. Anne Douglass gave a talk at a high school in Grass Valley, California, on results from UARS, and the plans for Aura. John Haberman worked with teachers and staff at the Owens Road Elementary School, G. Gardner Shugart Middle School, and Gwynn Park Middle School, all in Prince Georges County, to make operational their classroom and resource computers and computer networks. Dr. Haberman visited individual classrooms and discussed science and space topics of interest to teachers and students.

Academic Year Student Advising

The table highlights some of the advising activities of Laboratory members. Our scientists are on the thesis committees of the Masters and Ph.D. candidates.

School	Student Level	Financial Support	Advisor	Subject
UMBC	Grad	18K	Dave Whiteman	Aerosol extinction
UMBC	Grad	35K	Dave Whiteman	Lidar cirrus cloud measurements
Eleanor Roosevelt HS	Senior	NA	Chris Barnet	CO_2 retrievals
Instituto Nacional de Pesquisas Espaciais (INPE), Brazil	PhD	NA	Chris Barnet	AIRS validation
UMBC	PhD	NA	Chris Barnet	Remote sounding of Ozone
UMBC	PhD	NA	Chris Barnet	Remote sounding of CO
UMCP	Junior	68K	Geary Schwemmer	Instrument control for HARLIE instrument in field experiments
Politecnico di Torino, Turin Italy	Master of Engineering	NA	Richard Lawrence	Radar rainfall estimation
U. of Witwatersrand, Johannesburg South Africa	2 Master candidates	3K as GEST short term visitors	Anne Thompson	Atmospheric Sciences
U. of Alaska	PhD	NA	David Starr	Atmospheric Science
Eleanor Roosevelt HS	Senior	NA	John Haberman	Galileo probe instrument performance

Other Educational Outreach Activities

New Techniques and Strategies in Geoscience Education

Shepherd, J.M., 2002. “Science Education Supporting Weather Broadcasters On-air and in the Classroom with NASA ‘Mini-Education Supplements,’” was submitted to the Journal of Geoscience Education, a refereed journal reporting on new techniques and strategies in geoscience education. The paper describes a project funded through GSFC DDF funds, which produced innovative “quick packages focusing on TRMM-related science topics” with standards-based education curricula for use by weathercasters and classrooms. The packages consist of “raw materials for TRMM-related science” in the form of science results, animations, interview footage, suggested narratives, and lessons. This approach was tested by 70–80 pilot weather broadcasters around the nation, including the Weather Channel. The education materials have also been employed in pilot programs by educators and are available at the TRMM and Earth Sciences Directorate Web sites.

Workshop Outreach

GPM Workshop on Applications and Outreach: The first GPM Applications Workshop was held on February 19–20 at the Greenbelt Marriott in Greenbelt, Md. The workshop convened several scientists, professionals, and educators from various fields to discuss the development of an applications strategy for GPM. The meeting was organized by Marshall Shepherd. For more information, see the GPM Monitor at http://gpm.gsfc.nasa.gov.

GLOBE Workshop: Lorraine Remer gave an overview of Earth system science at the GLOBE teacher's workshop on July 9. Using schematics, simple models, and physical demonstrations she explained the Earth's energy balance and the role of aerosols in the energy balance at a level these teachers could copy and bring into the classroom. Lorraine will continue to work with the GLOBE project, using student-measured aerosol optical thickness as validation for the MODIS aerosol products.

Workshop on Infectious Disease Outbreaks: Marshall Shepherd and George Huffman (along with several other code 900 scientists) attended a workshop at the USUMS campus in Bethesda along with ESSIC and U.S. Unified Military Services personnel to understand and forge potential partnerships on using remote sensing, modeling, and analysis to diagnose and predict infectious disease outbreaks. The goal of the workshop was to position the group to respond to an upcoming NIH NRA on bio-defense. Huffman and Shepherd represented NASA's interest from a precipitation, TRMM, and GPM perspective. Talk given at the workshop: Adler, R.F., G.J. Huffman, D.T. Bolvin, E.J. Nelkin, and J.M. Shepherd, 2002: Quasi-Global, Multi-Sensor Precipitation Estimates from GPCP, TRMM, GPM. Planning Retreat on Biosecurity Proposal to NIH, 1 August 2002, Bethesda, Maryland.

Science Organization Outreach

AMS: At the invitation of the District of Columbia chapter of the American Meteorological Society, Robert Atlas agreed to serve on a panel of experts to discuss Careers in Atmospheric Science at the D.C. chapter's follow-up meeting. The meeting, held March 20th, at Washington-Lee High School, Arlington, Virgina, was an opportunity for us in the atmospheric science community to enhance the awareness of parents and teenagers of the wide variety of potential jobs in atmospheric science and related areas. Anne Thompson was a Career Speaker at the AMS Student Conference.

Project Outreach

Alma College and CPL: Under the direction of Matt McGill, the Cloud Physics Lidar (CPL) outreach activity continued in 2002. As in previous years, faculty and students from Alma College (a small 4-year college in Michigan) participated with the CPL personnel during the CRYSTAL-FACE field campaign. During CRYSTAL-FACE, one faculty member and one student from Alma College traveled to Key West and participated in data collection and analysis. During the school year, the student(s) and faculty work to infuse NASA remote-sensing data into the physics curriculum at Alma College, and the student(s) participates in directed study activities, using CPL data. This outreach activity is directly funded by CPL, under the direction of the P.I., Dr. Matthew McGill.

Charles Jackman: Training for Future Satellite Operators: The TOMS, UARS, and ERBS missions are currently being operated in conjunction with the Space Operations Institute of Capitol College. Besides providing useful atmospheric measurements, these three satellites are allowing undergraduate college students an incredible educational opportunity to receive training in satellite operations. Eight students are involved in this program with two students assigned to TOMS, three to UARS, and three to ERBS. The students work with professional engineers and are learning all aspects of satellite operations. This activity was started October 1, 2002, and it is hoped that it will continue through September 30, 2005.

Education and Outreach Colloquia

David Herring of the Climate and Radiation Branch hosts the monthly series of education and outreach colloquia, which has the goal of coordinating and improving the education and outreach activities of the Directorate.

Collaborations with University Faculty

David Starr helped Professor Sandra Cruz-Pol, University Puerto Rico–Mayaguez, develop a successful FAR proposal for a student project (provided feedback on proposal and additional NASA contacts).

Cooperative Agreements with Universities

Geary Schwemmer supports 3–4 undergraduate students at Utah State University on a cooperative agreement funded at $22K/year.

Public Outreach

Informing the public of how their tax dollar investments are working for them within the Laboratory is a critical subset of the Center and Agency public outreach mission. Laboratory scientists, working with other Laboratories at Goddard and outside institutions, continue to pass their knowledge and interest in Earth and space science to the general public via public information and education programs. Our scientists and engineers have been interviewed by the news media, have appeared in press conferences, have generated Web sites, CDs, and educational material oriented toward the general public, and have participated in public forums.

FTP Sites

Warren Wiscombe maintains an anonymous ftp site that is widely used for software by graduate students and colleagues.

Web-Based Outreach

Richard McPeters works on maintaining the TOMS Web site, which offers ozone data from TOMS on a near real-time basis-12 hour refresh. This site is heavily used by both external researchers and students, especially during ozone hole season.

Radio & TV Outreach

On March 26, 2002, “Earth and Sky” broadcast an interview with Yoram Kaufman on measurements of aerosol absorption of sunlight using AERONET and Landsat based on a paper with Tanre, Karnieli, Remer and Dubovik.

On May 1, Marshall Shepherd, David Adamac, and Claire Parkinson participated in a live morning TV press campaign in support of the upcoming Aqua launch. The scientists conducted live interviews via satellite with various TV stations around the country and fielded questions on the water cycle, weather, and climate and how new systems like Aqua will advance science understanding.

Laboratory for Atmospheres Support of NASA HQ Outreach

On April 23, at the request of NASA HQ, Marshall Shepherd spoke to a group of students in Annapolis to support NASA’s involvement with the Volvo Ocean Race. Several Code 900 speakers have spoken on Earth science, atmospheric science, and ocean science in support of this effort.

The Smithsonian's National Museum of Natural History opened its exhibit on Global Links. This exhibit features El Niño and its impact on the environment and mankind. The exhibit was largely supported by NASA and is the first in a series. The next exhibit, opening in 2004, will feature atmospheric chemistry and the Aura mission.

Marshall Shepherd served on a career panel on August 12 that addressed the 2002 GSFC Cooperative Students on future career opportunities at NASA and GSFC.

GPM Project Office has commissioned a group consisting of Marit Jentoff-Nilsen, Mike Manyin, and Fritz Hasler to develop an animation for the GPM constellation. This animation will be used by Dr. Asrar as well as the GPM Project office.

Walter Hoegy on October 24 presented a talk outlining the science activities to the Goddard Principal Investigator Conference. This was an all-day conference for about 20 investigators from minority universities who have received NASA grants.

Marshall Shepherd and Horace Mitchell on December 10 gave an overview of Earth science results and visualizations to Dr. Adena Loston, the new NASA Associate Administrator for Education. The overview and demonstration were presented at the Scientific Visualization Studio in bldg. 28. Along with Dr. Loston, the delegation included members of her HQ staff, Director Al Diaz, Janet Ruff, and PAO staff.

Popular Press

Marshall Shepherd has been asked to contribute an article to the popular magazine, Weatherwise, highlighting the use of NASA satellites for weather monitoring and prediction. The article will appear in an issue in 2003.

Outreach Effect from Refereed Publications

Media Attention to TRMM Paper on Urban Heat Island Rainfall by Shepherd et al., 2002, paper in the Journal of Applied Meteorology received high-level media attention. There were about 40 total stories airing in 29 U.S. markets from the TRMM Urban Heat Island Rainfall story.

Judging and participation at science fairs, etc.

Ryan Caveney judged Senior Division Physics at the 46th Annual Montgomery Area Science Fair, Montgomery County Community College, Rockville, Maryland, March 17, 2002.

Warren Wiscombe judged Blake High School Science Fair, spring 2002.

Richard Lawrence served as a judge for the outstanding student paper award, AGU.

Lena Iredell judged the Elementary School Science Fair, Annapolis, Maryland, and the Middle School Science Fair, Upper Marlboro, Maryland.

John Haberman judged a number of elementary and middle school science fairs in Prince Georges County; he also judged at the countywide "Kids for Science" Science Fair where only the "top 1%" of the projects from the schools are eligible.

TRMM Outreach/Education

TRMM continues its comprehensive Education/Outreach program, in which Laboratory personnel promote TRMM science and technology to the public under the leadership of the TRMM Project Scientist Robert Adler (910) and TRMM Education and Outreach Scientist Jeffrey Halverson (912/JCET). TRMM has included the development of broadcast visuals and educational curricula focusing on the Tropical Rainfall Measuring Mission. These packages are available on the TRMM Web site (http://trmm.gsfc.nasa.gov/) and have been reviewed as a part of the ESE Education product review. They are currently under revision. TRMM scientists regularly appear on major media outlets (Earth and Sky Radio, CBS, NBC, ABC, and CNN) in support of the mission. In addition, Laboratory personnel have spoken at and conducted several outreach workshops in support of TRMM. Marshall Shepherd released a new Web site highlighting current mesoscale and TRMM-related research on rainfall modification by urban areas. The Web site address is http://rsd.gsfc.nasa.gov/912/urban. This Web site was completely designed and implemented by one of the Mesoscale Atmospheric Processes Branch's summer high school interns as a part of the Branch and Laboratory's outreach initiatives. Articles authored by Jeff Halverson and Marshall Shepherd, featuring the TRMM satellite and other NASA remote sensors, recently appeared in the national publication, Weatherwise. Images of hurricanes and floods as imaged by TRMM occasionally have appeared as Image of the Day on NASA's Earth Observatory.

GOES Web Server

This Web server continues to provide GOES images online, including full-resolution images of all sectors of the United States for the most recent two days. There are extensive scrapbooks of digital movies and pictures of important weather events observed by the GOES-8 through GOES-12 satellites since the first launch in 1994. The Remote Sensed Data (RSD) server (http:rsd.gsfc.nasa.gov) has been judged by NASA HQ to be one of the 20 most popular NASA Web sites during the year 2000. The science administrator of RSD supplies GOES-derived high-quality graphics and severe storm animations to the Visualization Analysis Laboratory (VAL), to GSFC Public Affairs Office (PAO), and directly to the public via the Internet. During active hurricanes, the GOES section of the RSD Web server is accessible to the general public.

EOS Terra Outreach Synopsis

The EOS Terra outreach effort under the direction of Yoram Kaufman (Code 913), Jon Ranson (Code 920), and David Herring (Code 913) is a coordinated effort to foster greater cooperation and synergy among the various outreach groups within the EOS community. This effort is intimately integrated with the larger, ongoing Earth Observatory (http://earthobservatory.nasa.gov/) and Visible Earth (http://visibleearth.nasa.gov/) projects. A sampling of these activities, described below, represents contributions from the diverse EOS community.

The Terra Project Science Office (Code 900) produced a Terra mission overview brochure as well as a general public brochure and poster. The brochures, poster, and many more images, animations, and information about Terra are available on the Terra Web site (http://terra.nasa.gov), which is also maintained by the Terra Project. Beginning in the spring of 2003, under the direction of the Terra Project Scientist (Ranson), a new video will be produced demonstrating Terra's new measurement capabilities and its ongoing contributions to Earth system science.

David Herring leads a core group of content developers for the Earth Observatory. This Web environment provides a NASA Web-based interactive magazine written in a popularized style where the general public can access timely satellite imagery and information about the Earth. It showcases new data visualizations and new science results from EOS and ESE missions. All resources produced for the Earth Observatory are freely available for use by the EOS community, the general public, museums, educators, students, public media, regional

stakeholders, environmental awareness groups, etc. While leadership for this site resides in Code 913, significant contributions to its development come from Codes 900, 902, 912, 921, 922, 923, 935, 971, as well as the Jet Propulsion Laboratory, Johnson Space Center, Langley Research Center, the DAAC Alliance, and other organizations outside of NASA.

Folded into the Earth Observatory operation is maintenance and development of NASA's Visible Earth (http://visibleearth.nasa.gov/)—a digital repository of Earth images, animations, and data visualizations stored at a range of resolutions. This site is design to scale up so as to provide the public with a one-stop portal for access to the superset of all publicly available NASA Earth imagery. The responsible civil servant for Visible Earth is Michael King, Code 900. Dr. King is the primary sponsor for this entire suite of activities.

As a new part of this task, David Herring was asked to advise the Earth Sciences Director, Dr. Franco Einaudi, on how to form a new strategic plan for education and outreach for all of Code 900. Herring has formed an Education and Outreach Committee as well as working subcommittees to begin developing the recommendations for this plan. This activity has been underway for roughly 1 year.

EOS Aura Education and Public Outreach Synopsis

The Laboratory for Atmospheres has responsibility for conducting the Education and Public Outreach program for the EOS Aura mission. Aura's Education and Public Outreach program has four objectives. The first objective is to educate students about the role of atmospheric chemistry in geophysics and the biosphere. The second objective is to enlighten the public about atmospheric chemistry and its relevance to the environment and their lives. The third objective is to inform geophysics investigators of Aura science, and thus enable interdisciplinary research. The final objective is to inform industry and environmental agencies of the ways Aura data will benefit the economy and contribute to answering critical policy questions regarding ozone depletion, climate change, and air quality.

To accomplish these objectives, the Laboratory has partnered with several institutions, which have established infrastructures that reach large audiences through formal and informal education. The GLOBE program and the American Chemical Society (ACS) will carry out formal EOS Aura education outreach effort. Grants are now in place with the American Chemical Society (ACS), the Smithsonian's National Museum of Natural History (NMNH), and the GLOBE Program, via Drexel University for the various educational and public outreach activities relating to atmospheric chemistry and the Aura mission. The grants have resulted in educational material that will reach tens of thousands of teachers and their students and millions of members of the general public. Creation and dissemination of additional education products will continue through launch.

GLOBE is a worldwide network of students, teachers, and scientists working together to study and understand the global environment. Students and teachers from over 10,000 schools in 100 countries are working with the science community to learn more about the environment by making observations at or near their schools and reporting their data through the Internet. The Aura/GLOBE connection includes partnering with the P.I.s of the GLOBE Aerosol and GLOBE Surface Ozone investigations. Through Aura, the Laboratory has funded the development of a GLOBE Special Measurement using a handheld UVA meter that is similar in design to the GLOBE Sun photometer. During the summer of 2002, Aura hosted a teacher workshop for middle- and high school educators on the GLOBE/Aura Atmosphere Monitoring project. The workshop featured presentations from Lab scientists including P.K. Bhartia, Nickolay Krotkov, Lorraine Remer, and Charles Ichoku. Since the Aura mission involves partners from Europe, their education and public outreach programs will also support the GLOBE international components. KNMI (OMI PI institution) has entered into an agreement with GLOBE Netherlands and Drexel University to support GLOBE aerosol and UVA measurements.

The American Chemical Society (ACS) publishes ChemMatters, a magazine for high school students, that is distributed to over 30,000 high school teachers in classrooms throughout the country. During the past two years, ACS, in partnership with the Laboratory, has published two special issues of ChemMatters that focused on EOS Aura. These magazines were not only distributed to regular subscribers; they were also mailed to every high school chemistry teacher in the country. The September 2002 issue highlighted the "People of Aura" with articles profiling the scientists and engineers who are part of the Aura project. Anne Douglass (Aura Deputy Project Scientist) was the subject of one of the articles. Both the September 2001 and the 2002 issues were designated "Outstanding Products" in the semi-annual Earth Science Enterprise Education Products Review (http://www.strategies.org/2002ESEReview/Rec1997_2002.html). In an effort to promote the mission and the ChemMatters special issues, Aura EPO with ACS staff gave presentations at three regional NSTA (National Science Teachers Association) meetings in the fall.

Our outreach to the general public includes an exhibit at the Smithsonian Institution National Museum of Natural History (NMNH) and contributing feature and reference stories to the NASA Earth Observatory Web site. NMNH has millions of visitors per year. We are supporting an exhibit that is part of the "Forces of Change" Global Links Gallery. The exhibit is built around an Earth system science theme and tells 'stories' around components of the Earth' system. Work on the Aura-related "More than Meets the Eye" story of the chemistry of the atmosphere is in development and will open in June 2004. It will include modules on the Aura science questions and will also link to Aura data and GLOBE surface ozone, aerosol and UVA data. The museum will also develop a tool kit that will allow components of the exhibit to be portable and, thereby, available to other museums in the United States and abroad.

The Earth Observatory is one of NASA's premiere outreach Web sites. To date, Aura EPO staff have contributed six articles for the site that focus on atmospheric chemistry and Aura science. Four of the articles are on the site (published), one is submitted, and one is being revised.

- *Ultraviolet Radiation: How It Affects Life on Earth*, published
- *Highways of a Global Traveler*, published
- *The Ozone We Breathe*, published
- *Chemistry in the Sunlight*, published
- *Watching Ozone Weather*, submitted to editor
- *Tango in the Atmosphere: Ozone and Climate Change*, in revision

For further information, see the Aura Web site at http://eos-aura.gsfc.nasa.gov/outreach.

NASA/NOAA: Earth Science Electronic Theater 2002

The NASA/NOAA Earth Science Electronic Theater (E-Theater) uses HDTV display at up to IMAX size to deliver powerful visualizations promoting Earth science. Scientists from the various Earth science disciplines work directly with the Visualization Analysis Laboratory (VAL) team to develop scientifically accurate visualizations. E-Theater visualizations are rendered at High Definition TV (HDTV) quality, the highest resolution that can be easily distributed. The visualizations are also available in lower resolutions such as standard definition TV and as QuickTime movies. Multiple resolution versions of each E-Theater visualization are being added to the E-Theater Web page (http://Etheater.gsfc.nasa.gov/index.html/) and the Visible Earth Web page (http://visibleearth.gsfc.nasa.gov) along with an explanation of the scientific significance and the origin of the data. The Electronic Theater has been presented at universities, high schools, grade schools, museums, and Government laboratories as well as to scientists and the general public. E-theater presentations were made on a daily basis at the Children's Museum of Utah during the 2002 Winter Olympics in Salt Lake City. NASA visualiza-

tions also appeared during the Olympic Ceremonies and on Network and international television during the Games. The E-theater has recently been on a one-month tour of South Africa and has visited Montreal and Harvard University.

Visualization Technology & Display Development

The VAL, as well as other Goddard and NASA visualization groups, continues to produce visualizations using Earth science data from NASA, NOAA, and our international partners. These visualizations continue to be shown around the world using new display technologies. The VAL is a leader in the production of HDTV movies using low-cost editing systems. The VAL has pioneered and continues to develop low-cost systems to display HDTV movies using MPEG2 servers and the latest video projector and plasma screen display technology.

The VAL has developed methods for visualizing and interpreting immense remote-sensing data sets and 3-dimensional numerical models. We call the data from many new Earth-sensing satellites HyperImage data sets, because they have such high resolution in the spectral, temporal, and spatial domains. The traditional numerical spreadsheet paradigm has been extended to develop a scientific visualization approach for interactively processing HyperImage data sets and 3-D models. The advantages of extending the powerful spreadsheet style of computation to multiple sets of images and organizing image processing were demonstrated using the Distributed Image SpreadSheet (DISS). The DISS has been used as a high performance testbed application for the Next Generation Internet (NGI).

Museum Support

The Visualization Analysis Laboratory, VAL, actively works with large and small museums in creating new, innovative Earth science displays. Some of these museums include the National Museum of Natural History, the National Air and Space Museum, the American Museum of Natural History in New York City, the Virginia Science Center, The Children's Museum of Utah, and the Houston Museum of Natural History.

One successful museum activity is the permanent "Earth Today" exhibit of near real-time Earth science data displays at the Smithsonian National Air and Space Museum—the most visited museum in the world. These near real-time data presently include global cloud cover, global water vapor, sea surface temperature, sea surface temperature anomalies, biosphere, and earthquakes. VAL personnel are developing an upgraded extensible version of this exhibit that will allow its adoption by other museums.